FEDERAL SCIENTIFIC CORPORATION

615 WEST 131ST STREET • NEW YORK, N. Y. 10027 • AUDUBON 6-4400

T. Nelson, Systems Consult
Box 1546
Poughkeepsie, N.Y. 12603

Date: ______________

THANK YOU FOR YOUR INTEREST!

THE ATTACHED INFORMATION IS FOR YOUR IMMEDIATE USE.

PLEASE FEEL FREE TO CALL ME OR ONE OF OUR ENGINEERS AT ANY TIME SHOULD YOU REQUIRE ADDITIONAL INFORMATION.

SINCERELY YOURS,

FEDERAL SCIENTIFIC CORP.

Harold Klipper

HAROLD KLIPPER
TECHNICAL ASSISTANT
TO THE PRESIDENT

FEDERAL SCIENTIFIC CORPORATION

Date ______________________

Name ______________________ Title ______________________

Dept. ______________________ Mail Station ______________________

Company ______________________

Address ______________________

City ______________________ State ______________________

Phone No. ______________________ Extension ______________________

COMPANY INFORMATION: ☐ Mfg. of (product) ______________________

☐ R&D of (type) ______________________ Other ______________________

I buy ☐ specify ☐ maintain ☐ use ☐ instruments.

Please keep ☐ remove ☐ my name from mailing list.

I am interested in:

- ☐ Ubiquitous™ Spectrum Analyzer
- ☐ Immediate System Characterizer™
- ☐ Real-Time Contour Spectrograph™
- ☐ Intensigraph™ Recorder
- ☐ Other ______________________

Model No. ______________________

Please:

- ☐ Contact me as soon as possible
- ☐ Have local representative contact me
- ☐ Rush information
- ☐ No hurry, for future application
- ☐ Information for file catalog

If you have a specific measurement problem, there may be an FSC instrument, of which you are not aware, which would be of use in your application. FSC specializes in providing real-time measurement systems and instrumentation for numerous fields, including: radar, acoustics, underwater acoustics, statistical analysis, spectrum analysis, vibration, sound, strain, psychoacoustics, etc. If you will describe your requirement below an FSC engineer may be able to assist you.

What measurements do you need to make? ______________________

Frequency range? ______________________ Amplitude range? ______________________

In what form do you want the results presented?

Other pertinent details (such as applicable specifications or standards):

What does your company gain from making this measurement?

Our recommendations will be used for:

- ☐ Immediate application (within 2 months)
- ☐ Probable application (2 to 10 months)
- ☐ Immediate planning
- ☐ Reference file
- ☐ Bidding purposes
- ☐ Self-educational purposes

Requirement is for use on project ______________________

My area of activity is ______________________

FOLD HERE FIRST

Postage
Will be Paid
by
Addressee

No
Postage Stamp
Necessary.
If Mailed in the
United States

BUSINESS REPLY MAIL
First Class Permit No. 17073, New York, N. Y.

FEDERAL SCIENTIFIC CORP.

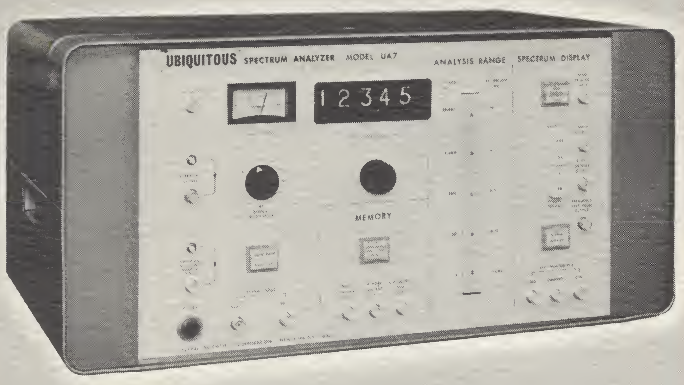
615 WEST 131ST STREET

NEW YORK 27, N. Y.

FOLD HERE LAST

FOLD HERE SECOND

Technical Bulletin 662
July 1966



FEDERAL SCIENTIFIC CORPORATION

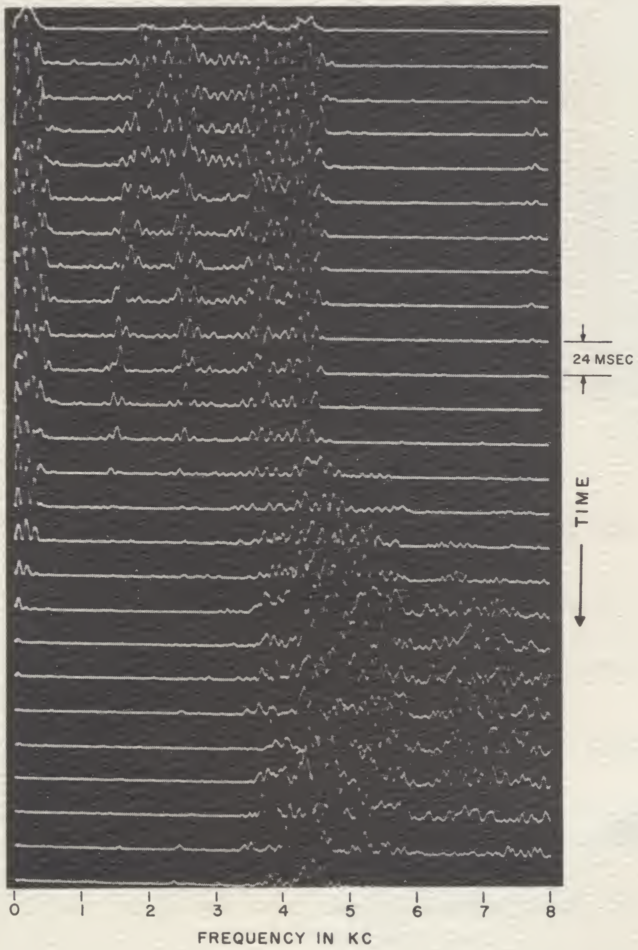
615 West 131st Street
New York, N.Y. 10027
(212) 286-4400

UBIQUITOUS™ SPECTRUM ANALYZER – MODEL UA7

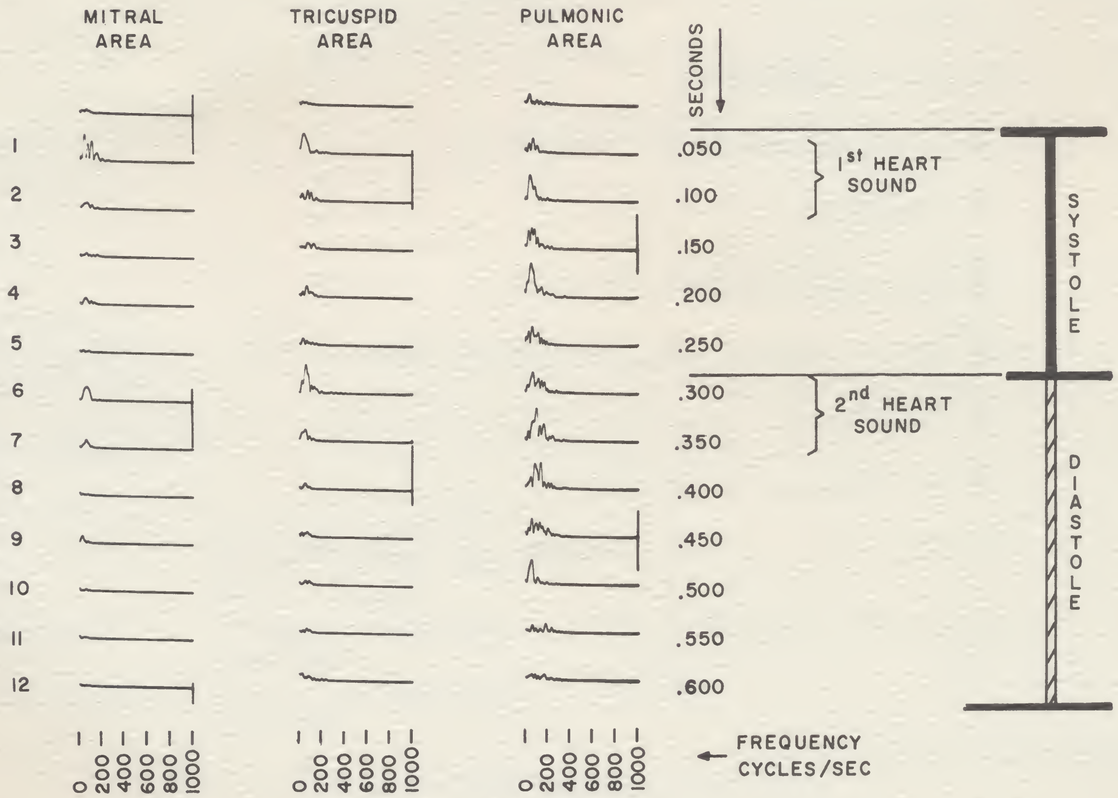
- Real-Time Analysis of All Frequencies Simultaneously
- Resolution from 20 Hz to 0.002 Hz
- Captures and Stores Transients
- Synthesizes Thousands of Simultaneous Frequency Resolution Elements
- Compatible with All Recorders and Oscilloscopes
- Extremely Reliable, Compact, and Light

Fields of Application

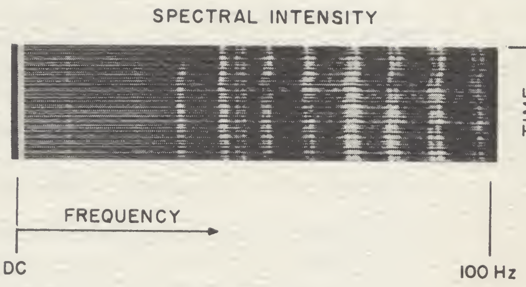
- Vibration and Shock Analysis
- Acoustics
- Automatic Speech Recognition
- Radar Doppler and Scintillation Measurement
- Geophysics
- Biophysics and Medicine
- Extraction and Identification of Weak Signals in Noise
- Fourier Analysis

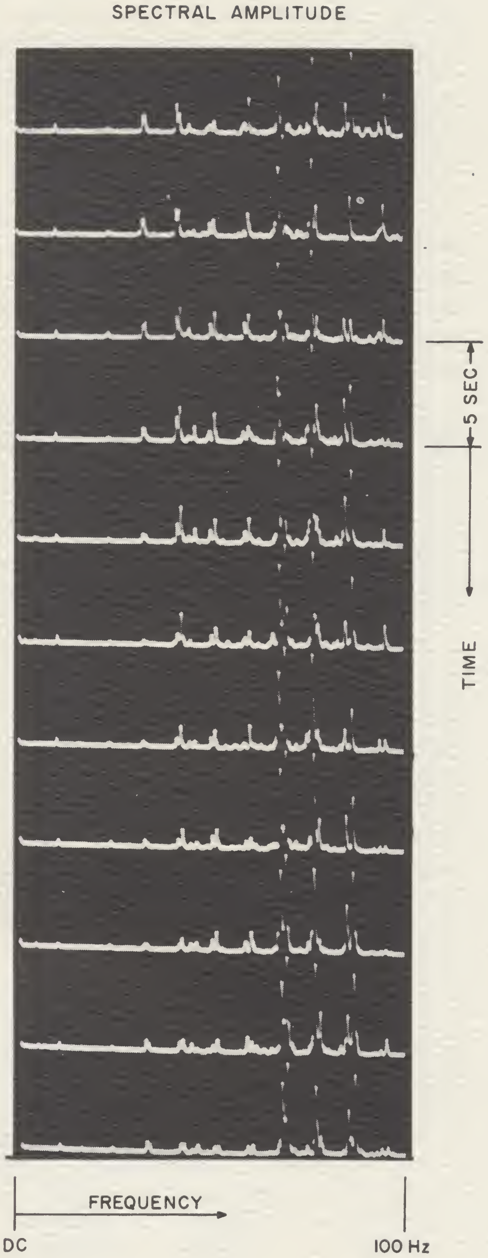


Chronological spectrograms of the word "IS." The freqency resolution is 54 Hz, and the time between successive spectrograms is 24 milliseconds. During the initial portion of the word, which is voiced, the downward migration of formant 2 and the constancy of formant 3 and pitch frequency can be noted. During the second half of the word, the termination of voicing and the high-frequency "white" spectrum of the sibilant are seen. The transition from the voiced to sibilant sound transpires in about 50 milliseconds. The entire word is pronounced in about 0.6 second.



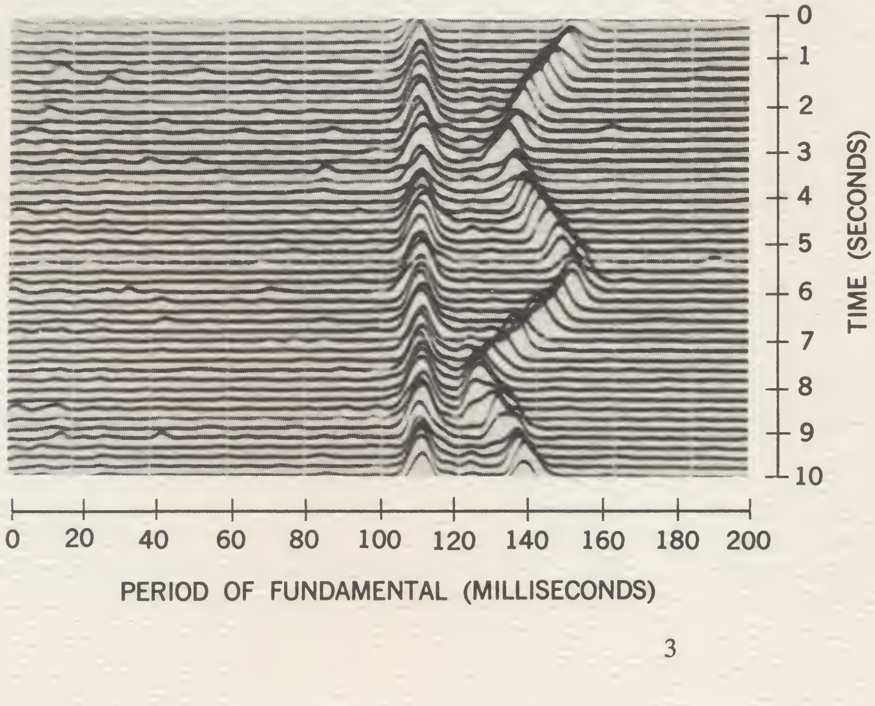
Chronological spectrograms of heart sounds in patient with patent *ductus arteriosus*. The frequency resolution is 20 Hz, and the time between successive spectrograms is 50 milliseconds.





Amplitude and intensity-modulated displays of chronological spectrograms of machinery vibration. The time between successive spectrograms is 5 seconds, and the total time spanned by the sequence of spectrograms is 50 seconds. The frequency resolution is 0.2 Hz.

Iterated spectrum analysis ("cepstrum") of two pulse trains in noise. The conventional spectrum analysis of the pulse trains is first obtained, exhibiting the two fundamental frequencies and their harmonics. The Ubiquitous™ Analyzer output maps frequency linearly into the time domain, permitting the spectrum to be reinterpreted as a new time function. The harmonic nature of the original pulse train spectra causes periodicities in the new time function, which a second spectrum analysis extracts. In the second spectrum analysis, the power of all the pulse train harmonics is accumulated constructively to identify the repetition period of the two signals, without mutual interference and despite the poor original signal-to-noise ratio. One signal has a steady repetition period of 110 msec, while the other period fluctuates between 125 and 155 msec. The analysis shown required 10 seconds in real time.



Ubiquitous™ Spectrum Analyzers perform real-time Fourier analysis at all frequencies simultaneously, within the selected analysis band. The voltage or power spectral density is obtained for continuous signals, intermittent signals, and one-shot transients. The name "Ubiquitous™" denotes the ability of this instrument simultaneously to observe each and every frequency component continuously (with 100 percent duty cycle), and to present the Fourier analysis of all frequencies in real time. This ability is extremely useful when one desires to observe the complete spectrum of a dynamic process in real time, or when the quantity of Fourier analyses required renders other techniques too cumbersome and costly.

The simultaneous equivalent of thousands of contiguous bandpass filters are synthesized by the Ubiquitous™ Spectrum Analyzer within a single signal path; as a result the synthesized resolution elements possess a stability and uniformity that are unattainable by other techniques. The use of exclusively solid-state circuitry, with the majority of circuits integrated, results in extreme reliability, small size, and low power consumption.

An internal memory can capture "snapshots" of one-shot transients or desired portions of continuous or intermittent signals. The signal in storage is Fourier-analyzed, and also presented in the time domain at an output terminal for examination on a convenient time base in parallel with the spectrum presentation. This capability can supplant tape loops, storage oscilloscopes, and the like. The coordinated time-domain and frequency-domain displays are of great advantage in many applications, and can be used both continuously and with transient signals.

A broad selection of spectrum-analysis characteristics is available in the Ubiquitous™ Analyzer. Five decade ranges of analysis parameters are obtainable by front-panel push-button selection. The characteristics of the five ranges are listed in Table I.

TABLE I
SPECTRUM ANALYSIS CHARACTERISTICS

Analysis Range	Location of Analysis Range Hz	Width of Analysis Range Hz	Bandwidth of Synthesized Filter Hz
A	20 to 1,000,000	10,000	20
B	2 to 1,000,000	1,000	2
C	Direct Input	100	0.2
D	Direct Input	10	0.02
E	Direct Input	1	0.002

Definitions of Terms

Location of analysis range — position of the low-frequency end (origin) of the analysis range. In Ranges A and B the origin can be placed anywhere up to 1 MHz through the use of an internal frequency converter consisting of a very linear mixer and a stable tunable local oscillator.

Width of analysis range — the width of the interval in the frequency domain which is Fourier-analyzed simultaneously. In Ranges A and B the instrument's internal frequency converter permits this analysis interval to be placed at any location up to 1 MHz.

Bandwidth of synthesized filters — the nominal resolution bandwidth. This value, which is the reciprocal of the time duration of the input signal contributing to the spectrum analyzer output, determines the noise bandwidth in a system in which the Ubiquitous™ Analyzer serves as the final signal resolution stage.

Spectrum Display Periods

Spectrum display periods of 0.05 seconds, 0.5 seconds, 5 seconds, and 50 seconds are selectable with a front-panel control. The spectrum-display period is the time required for the display of one complete spectrum analysis covering the full width of the selected analysis range.

The shortest display period provides a flickerless oscilloscope presentation with 20 analyses per second. The longer display periods permit direct recording of the spectrum analysis on mechanical recorders and plotters.

Any display period can be employed with any Analysis Range. In order to keep up with the possible fluctuation of the spectrum of a dynamic signal, it is necessary to choose a spectrum display period which does not exceed the reciprocal of the filter bandwidth selected. However, if the signal is a one-shot transient or a segment of a continuing signal, it can be captured in real time by the internal memory and displayed in the frequency domain at any selected rate.

Provision is made for the spectrum scan to be either free-running or synchronized. A linear sweep voltage is provided at an output terminal which can be used for the frequency axis of oscilloscopes and recorders. Trigger pulses to synchronize displays of the spectrum and the time-domain signal presentations are provided at trigger output terminals.

Number of Filters Synthesized

The number of equal-bandwidth synthesized filters of completely uniform frequency characteristics covering the analysis range varies between 500 and 500,000, depending on the spectrum display period selected. The relation between the spectrum display period, the number of filters synthesized. and the filter spacing is given as follows:

TABLE II
DISPLAY PERIOD, NUMBER OF FILTERS SYNTHESIZED AND FILTER SPACING

Display Period seconds	Number of Filters Synthesized	Filter Spacing
0.05	500	1 bandwidth
0.5	5,000	0.1 bandwidth
5	50,000	0.01 bandwidth
50	500,000	0.001 bandwidth

The selection of a spectrum display period associated with the synthesis of 5,000 filters or more results in a quantization of the frequency axis so fine that the obtainable frequency resolution practically reaches the theoretical limit imposed by the signal-to-noise ratio and the bandwidth of the synthesized frequency-resolution elements.

Time-Domain Display

The waveform in storage in the digital memory is available in analog form at an output terminal. Regardless of the rate at which the signal was supplied to the Ubiquitous™ Analyzer, the entire contents of the memory can be displayed with a repetition period of less than one millisecond.

Transient Capture Mode (replaces tape loops and storage oscilloscopes)

The internal digital memory can be made fully retentive for the purpose of obtaining and analyzing "snapshots" of one-shot transients or selected segments of continuous signals. The retained waveform is available in analog form for repeated display in the time domain while its spectrum is analyzed.

Principle of Operation

Ubiquitous™ Analyzers perform storage and speed-up of the input signal to enable an extremely stable, precisely designed crystal filter to examine a very broad input spectrum rapidly.

The input signal is first heterodyned into the frequency band used internally by the analyzer. Then the input signal is fed to a high-quality analog-to-digital converter which converts it to digital form. The rate at which the signal is sampled is set conservatively in excess of sampling-theorem requirements in order to guarantee faithful extraction of the spectrum. The digitized samples are passed in parallel binary form to a digital memory. The sample values progress through successive positions in the memory at a rate which is very rapid compared to the input sampling rate. The digitized samples emerging from the memory output are fed back into the memory input and are sequenced with respect to newly obtained input samples so that the memory contains all the samples in the same order as they arrived originally in real time.

The time interval between consecutive samples taken from the input signal is extremely long compared to the interval between the emergence of successive samples from the memory. This situation results in a great contraction of the signal time base, or, equivalently, a dilation of the signal's frequency spectrum. This operation

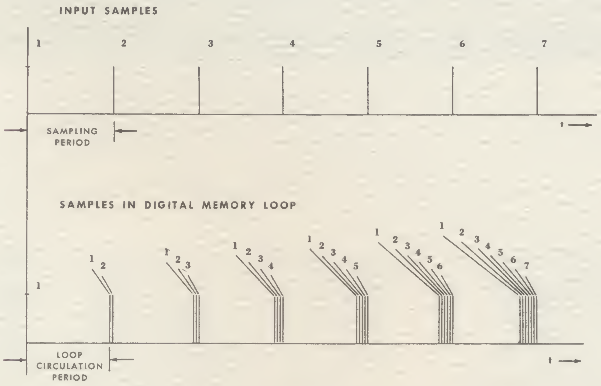


Fig. 1 Timing Diagram Illustrating the Sample and Speed-up Technique

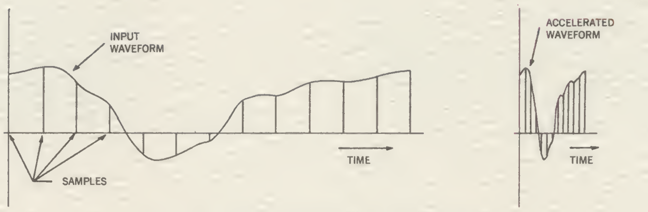


Fig. 2 Waveform Acceleration

is illustrated in Figs. 1 and 2. It is thus made possible for a wide-bandwidth filter to examine the dilated spectrum with the same net frequency resolution as a narrow-bandwidth filter operating on the unaccelerated input signal. However, the settling time of a wide-bandwidth filter is very short, so that it can be moved rapidly through the dilated signal spectrum. The speed-up factor is chosen to permit the entire spectrum to be analyzed by one broad bandwidth filter in the time that would have been required to examine a single resolution element with the same equivalent resolution at the input. A real-time simultaneous analysis is thereby obtained.

The mathematical consequence of compressing the signal's time base in this manner can be demonstrated by examining the effect it produces on the signal's Fourier integral, or spectrum. Let the input signal be $s(t)$, and let its Fourier transform be $S(f)$.

$$S(f) = \int_{-\infty}^{\infty} s(t) \exp\left\{-j2\pi ft\right\} dt$$

Let the temporal speed-up factor be k. Then the accelerated signal can be written as $s(kt)$. The Fourier transform of the accelerated signal is:

$$\mathcal{F}\left\{ s(kt) \right\} = \int_{-\infty}^{\infty} s(kt) \exp\left\{-j2\pi ft\right\} dt$$

$$= \frac{1}{k} \int_{-\infty}^{\infty} s(kt) \exp\left\{-j2\pi \frac{f}{k} tk\right\} dkt$$

$$= \frac{1}{k} S\left(\frac{f}{k}\right)$$

It is evident that the accelerated signal possesses a spectrum $S(f/k)$ of precisely the same form as $S(f)$, but with corresponding frequency components separated k times as much.

The digital memory output is fed to a digital-to-analog converter. The output of this converter is the accelerated replica of the original input signal. It is applied to the stable crystal filter via a heterodyner which causes the crystal filter to observe successive frequency-resolution cells in sequence. The settling time of the crystal filter is short enough to permit it to make a completely fresh observation each time the digital memory undergoes one recirculation. The output of the digital-to-analog converter is also supplied to a front-panel output terminal to allow continuous observation of the signal circulating in the memory.

OPTIONAL USE
1 VRMS INTO 1,000 OHMS PROVIDES INPUT TO AN EXTERNAL FREQUENCY COUNTER

METER AND ATTENUATOR TO ASSURE EFFICIENT USE OF 48 db DYNAMIC RANGE. 60 db ATTENUATOR, CALIBRATED IN 5 db STEPS

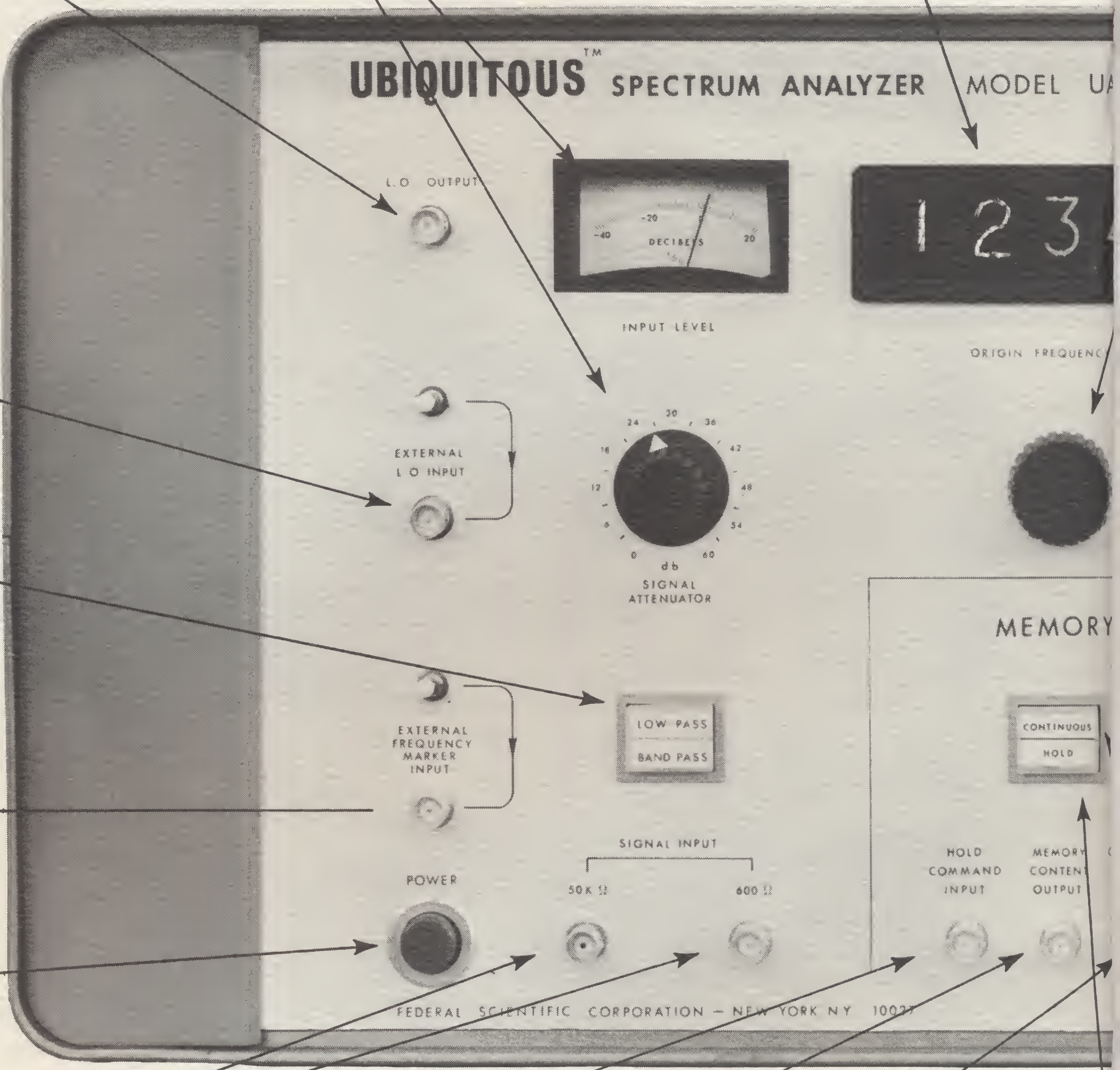
DIGITAL DISPLAY OF INTERNAL FREQUENCY COUNTER INDICATES ORIGIN OF ANALYSIS RANGE SET BY LOCAL OSCILLATOR

OPTIONAL USE
0.3VRMS, 1,000 OHMS

IN "LOW PASS" POSITION ORIGIN OF ANALYSIS RANGE IS ZERO FREQUENCY; IN "BAND PASS" POSITION ORIGIN OF ANALYSIS RANGE IS CONTROLLED BY INTERNAL OR EXTERNAL OSCILLATOR

OPTIONAL USE
0.1VRMS, 1,000 OHMS

ON-OFF SWITCH, LAMP INDICATES AC POWER ON



INPUT TERMINALS 50,000 OHM AND 600 OHM INPUT IMPEDANCES

PULSE COMMANDS MEMORY TO RETAIN SIGNAL ARRIVING SUBSEQUENTLY; ACCEPTS 1 TO 10 μS PULSE, +6V, 1,000 OHMS

MEMORY CONTENTS (TIME FUNCTION) DISPLAYED IN ANALOG FORM; 0.5V P-P INTO 100 OHMS AC COUPLED

PULSE DENOTES BEGINNING OF CIRCULATION OF DIGITAL MEMORY; 1 μS PULSE, +6V INTO, 1,000 OHMS

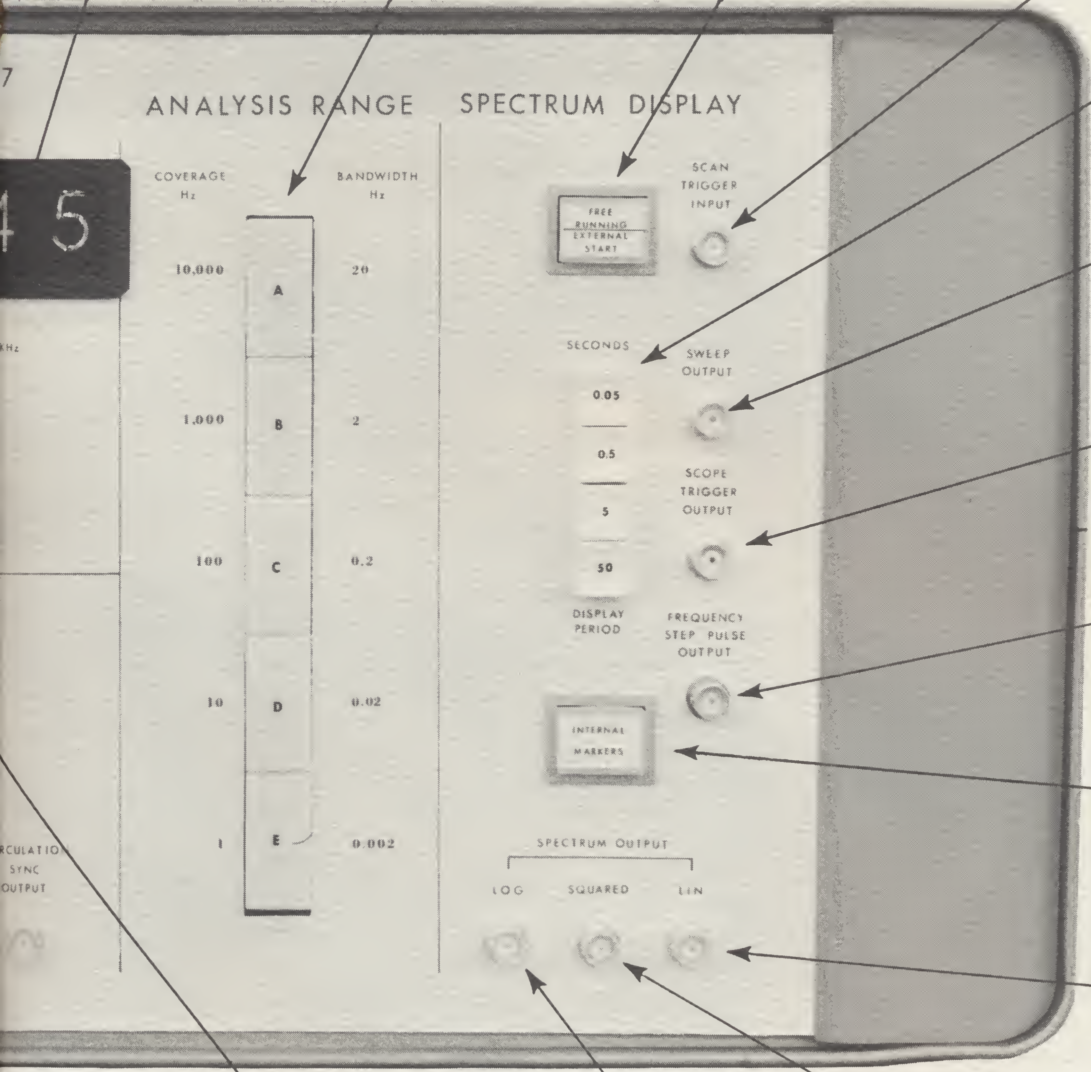
DEPRESSING S
PLACE IT IN "H
COMMANDS ME
RETAIN SIGNAL
IT AT THAT INS

ORIGIN FREQUENCY (INTERNAL LOCAL OSCILLATOR) TUNING KNOB

PUSH BUTTONS TO SELECT ONE ANALYSIS RANGE (SELECTED BUTTON LIGHTS UP)

FREQUENCY SCAN WITHIN ANALYSIS RANGE MADE "FREE RUNNING" OR EXTERNALLY SYNCHRONIZED BY "SCAN TRIGGER" PULSE

PULSE 1 TO 10 μS, +6V, 1,000 OHMS; TO START SPECTRUM SCAN IN "EXTERNAL START" MODE



SPECTRUM DISPLAY PERIOD SELECTED BY ONE PUSH BUTTON

LINEAR SWEEP FOR FREQUENCY AXIS DEFLECTION OF DISPLAY OR RECORDER; 0 TO +2V INTO 1,000 OHMS, DC COUPLED

1 μS PULSE TO TRIGGER DISPLAY OSCILLOSCOPE SWEEP; +6V INTO 1,000 OHMS

PULSE DENOTES DISPLAY IS MOVED TO NEXT FREQUENCY RESOLUTION ELEMENT; 1 μS PULSE, +6V INTO 1,000 OHMS

PRESS TO OBTAIN 10 UNIFORMLY SPACED INTERNALLY GENERATED FREQUENCY MARKERS

LINEAR (UNCOMPRESSED) SPECTRUM OUTPUT, +5V PEAK INTO 600 OHMS

ITCH TO
LD" POSITION
MORY TO
WITHIN
ANT

DEPRESSING SWITCH TO PLACE IT IN "CONTINUOUS" POSITION CAUSES CONTINUOUS MEMORY REPLENISHMENT

LOGARITHMICALLY COMPRESSED SPECTRUM OUTPUT FOR EASE IN DISPLAYING SIGNALS WITH LARGE DYNAMIC RANGES +5V PEAK INTO 600 OHMS

OPTIONAL FEATURE SQUARE-LAW SPECTRUM OUTPUT FOR POWER SPECTRAL DENSITY MEASUREMENT; +5V PEAK INTO 600 OHMS

BLOCK DIAGRAM DESCRIPTION OF THE UBIQUITOUS™ SPECTRUM ANALYZER

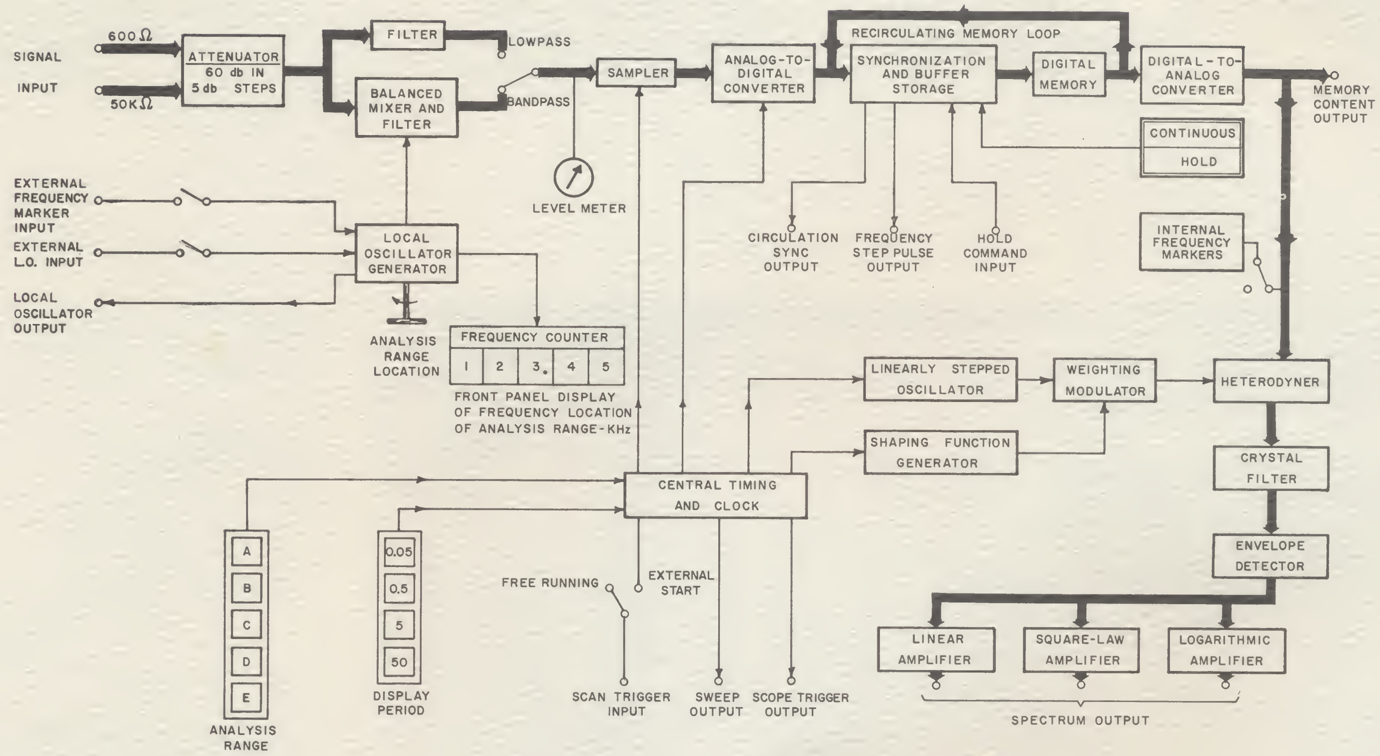


Fig. 3 Block Diagram of the Ubiquitous™ Spectrum Analyzer

Two input terminals are provided to facilitate matching impedance levels. One terminal presents a 50,000-ohm impedance and the other presents a 600-ohm impedance. The signal is fed to a front-panel attenuator possessing a 60-db range with 5-db calibrations. A level meter permits the attenuator to be set so that the signal optimally occupies the dynamic range of the subsequent digital circuitry.

Placing the *Low Pass-Band Pass* switch in the *Low Pass* position causes the signal to be applied to a sampling circuit through a low-pass filter. This filter restricts the signal spectrum to a value equal to the frequency-coverage width of the analysis range chosen as listed in Table I. This restriction is necessary to ensure that sampling will not cause spectral distortion of any kind. The sampling rate is set safely in excess of the value required by the sampling theorem in order to guarantee complete fidelity. If the input signal is not originally located at the low end of the spectrum, it is necessary to translate it to the low end before sampling; this is accomplished in the balanced mixer when the switch is in the *Band Pass* position, and permits the frequency interval under analysis to lie anywhere between near zero and 1 MHz. A filter in the balanced mixer restricts the spectral width of the signal to the value equal to the coverage width of the analysis range chosen.

The samples are fed to an analog-to-digital converter. In the standard model, the converter produces 9-bit binary words. Extreme linearity is maintained in the analog-to-digital conversion; no amplitude compression, saturation, or other non-linearities are allowed, since they could result in intermodulation between signal components leading to the generation of spurious components or the extinction of weak frequency components.

The digitized samples are placed in a buffer storage before being fed to the recirculating digital memory. The timing is arranged so that successive samples are placed in the memory in the same order in which they originally arrived at the input to the spectrum analyzer, but the time between consecutive samples in the memory is extremely small compared to the inter-sample period of the original waveform. The output of the recirculating digital memory loop is converted to analog form by the digital-to-analog converter. The converter output is supplied to the *Memory Content Output* terminal on the front panel to permit continuous observation of the signal in the memory. The analog waveform from the converter is also fed to the heterodyner for frequency analysis by the crystal filter.

The Transient Capture Mode

In the usual mode of continuous operation, the Synchronization and Buffer Storage unit discards the old-

est sample in storage when the memory is completely full and places the newest incoming sample in its place. This continually refreshes and updates the memory, producing the same replenishment that occurs with a conventional finite-memory filter. However, the user may prefer to capture a one-shot transient, or an especially interesting segment of a continuing signal, in the memory. This can be accomplished by inhibiting the sample replacement function of the Synchronization unit. When this is done, the memory contents will be retained indefinitely in recirculating storage, and may be viewed in the time domain at the *Memory Content Output* terminal while the spectrum is analyzed at leisure.

The Transient Capture Mode can be initiated in either of two ways. The first is by placing the *Continuous-Hold* switch in the *Hold* position. This causes the signal in the memory at that instant to be retained. The length of the retained signal depends on the *Analysis Range* selected, and is tabulated below. A light goes on in the *Hold* portion of the switch, indicating that the memory has been placed in the retentive condition. In order to terminate the *Hold* condition, the switch is placed in the *Continuous* position. This immediately restores the memory to the continuous replenishment mode, and the *Continuous* portion of the switch is illuminated.

The second means of initiating the Transient Capture Mode is to supply a pulse to the *Hold Command Input* terminal. The memory will retain the signal which arrives immediately subsequent to this pulse. The temporal length of the signal which the memory can retain depends on the *Analysis Range* selected, and is tabulated below. As soon as this length of signal arrives subsequent to the *Hold Command* pulse, the *Hold* portion of the switch is illuminated. This indicates that the signal in storage will be recirculated indefinitely. The *Hold* condition can be terminated by restoring the switch to the *Continuous* position. This immediately restores the memory to the continuous replenishment mode. The light in the *Hold* portion of the switch goes off, and the light in the *Continuous* portion goes on.

The rationale for having the *Hold* switch cause retention of the signal already in the memory, but having the pulse applied to the *Hold Command* terminal cause retention of the signal about to arrive, is the following: The user monitoring the signal at the *Memory Content* terminal will generally decide to retain the memory contents when he observes a signal of interest which, necessarily, has already occurred. Contrariwise, a trigger pulse applied to the *Hold Command Input* terminal will usually be generated at the beginning of a transient event.

TABLE III

LENGTH OF INPUT SIGNAL IN MEMORY

Analysis Range	Signal Length (seconds)	Width of Analysis Range (Hz)
A	0.05	10,000
B	0.5	1,000
C	5	100
D	50	10
E	500	1

Output

The output of the digital-to-analog converter is applied to the heterodyner where it is mixed with a sinusoid whose frequency is carefully stepped. The steps occur in synchronism with the recirculations in the digital memory. A new frequency component of the signal is heterodyned into the pass band of the crystal filter at each recirculation. The crystal filter thereby analyzes the entire spectrum of the signal by responding successively to adjacent frequency components. The dilation of the signal spectrum permits the settling time of the crystal filter to be very rapid, and so the entire spectrum can be examined in a short time. However, it may sometimes be desirable to record the spectrum on an X-Y plotter, or other mechanically deflected device, whose limited response rate does not permit it to follow the most rapid analysis rates of the Ubiquitous™ Spectrum Analyzer. In order to accommodate this possibility, a selection of spectrum display periods is provided by controlling the time taken by the Linearly Stepped Oscillator to move from one end of its frequency range to the other. This is accomplished by decreasing the size of the frequency steps, while keeping the dwell time at each step fixed and equal to the memory recirculation period. As the frequency increment between steps decreases, the number of resolution elements synthesized increases correspondingly. The relation between the spectrum display period, the frequency interval between resolution cells, and the number of equivalent filters synthesized is listed in Table II. (p. 4).

While 500 synthesized filters spaced one bandwidth apart permit an extremely good view of the spectrum, 5,000 synthesized filters spaced 0.1 bandwidth apart are practically equivalent to a continuum of resolution cells. Beyond this number of synthesized filters, almost no further advantage is gained because of the high degree of redundancy of overlapping resolution cells. However, long display periods with their slower output fluctuation rate permit the use of slow-response recorders.

Any display period may be employed with any analysis range. It should be noted, however, that, in order to take full advantage of the real-time analysis capability of the Ubiquitous™ Spectrum Analyzer, it is necessary to examine the entire spectrum often enough to observe the fluctuations of the output of each resolution cell. The time required for the output of a synthesized filter to fluctuate substantially is equal to the reciprocal of the filter's bandwidth. This assumes that the input signal is non-repetitive and possesses a spectrum that fluctuates at the fastest rate the analysis resolution will permit; if the input signal is repetitive, its spectrum will not fluctuate, and the outputs of the synthesized filters will not change.

The output of the crystal filter is linearly envelope-detected and fed to linear and logarithmic amplifiers. The linear amplifier output gives the absolute value of the voltage spectral-density function. The logarithmic amplifier gives the same result, but with logarithmic compression (equivalent to using a db scale) in order to make the small frequency components more visible. A

square-law amplifier can also be provided, as a special option, whose output gives the power spectral density of the signal in the memory.

A pulse is supplied at the *Frequency Step Pulse Output* terminal to denote the advance from each frequency resolution element to the next. A pulse is supplied at the *Scope Trigger Output* terminal to indicate the beginning of the spectrum presentation at the low frequency end of the frequency axis. A linear deflection waveform in synchronism with the frequency sweep is supplied at the Sweep Output terminal for use in providing the sweep voltage for displays which do not possess their own sweep generators. If it is desired to control the instant at which the frequency spectrum examination starts from the low frequency end, the *Free Running-External Start* switch should be placed in the *External Start* position and a pulse supplied at the desired instant to the *Scan Trigger Input* terminal.

Frequency Characteristic

The frequency selectivity characteristic of each synthesized resolution element is produced in the Ubiquitous™ Spectrum Analyzer through a technique which overcomes the usual restraints between the frequency selectivity of a filter and its transient response. A fixed parameter filter cannot simultaneously provide fine resolution in the frequency domain and rapid transient response in the time domain. As a result, a compromise between frequency selectivity and transient response is necessary, with the Gaussian characteristic often chosen as the most palatable allocation of dissatisfaction. The limitations of fixed-parameter filters are overcome in the Ubiquitous™ Spectrum Analyzer by taking advantage of the fact that the instants at which each circulation of the signal in storage begin and end are known precisely. This permits the parameters of the analyzing filter to be time-varied in synchronism with the passage of the signal around the recirculation loop, with a resulting substantial superiority over the characteristics achievable with fixed-parameter networks.

During each signal passage around the loop, the Shaping Function Generator provides an output to the Weighting Modulator which imposes the shaping function as amplitude modulation on the Linearly Stepped Oscillator input to the Heterodyner. The Heterodyner is a square-law stage operated well within the square-law portion of its characteristic, so that its output is proportional to the product of its two inputs; as a result, the signal arriving at the Crystal Filter is the output of the Digital-to-Analog Converter multiplied by the shaping function. The effect on the Crystal Filter output is the same as modifying the impulsive response of the Crystal Filter to include the shaping function. Through the choice of an appropriate shaping function, the frequency selectivity characteristic of a complex network can be produced while retaining the simple structure and rapid discharge characteristic of a singly-resonant filter. An additional advantage is that the frequency characteristic can be modified readily by changing the shaping function.

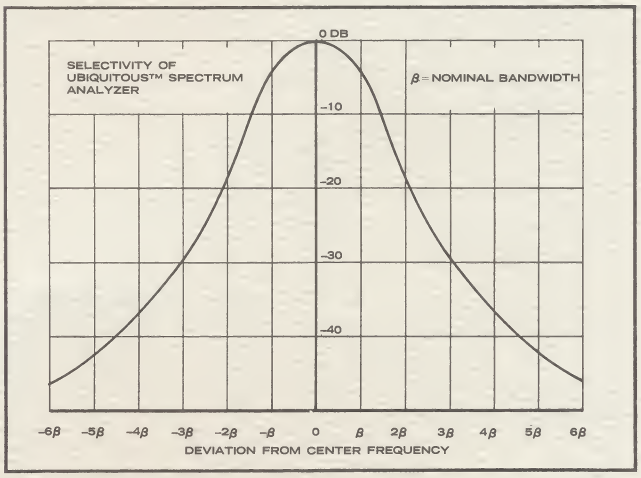


Fig. 4 Frequency Selectivity of the Ubiquitous™ Spectrum Analyzer — Standard Model

The frequency-selectivity characteristic supplied in the standard model Ubiquitous™ Spectrum Analyber is shown in Fig. 4. It has an asymptotic skirt slope of 18 db per octave. The parameter β is the bandwidth listed for each Analysis Range in Table I. Other frequency characteristics can be supplied upon request.

OPTIONS AND ACCESSORIES

The versatility of the Ubiquitous™ Spectrum Analyzer is extended by the availability of various optional features and accessories to accommodate the requirements of special applications. The following list contains items which are already being supplied to customers. New options and accessories will be added in response to new requirements. Your inquiries are solicited concerning features which do not appear in the list.

Option or Accessory No.

Input Options

11 93-ohm input impedance
12 75-ohm input impedance
13 50-ohm input impedance
14 Signal sampling instant controlled by an external command
15 Signal sampling instant controlled by reference sinusoid on tape, in order to compensate for flutter and wow of tape record
16 Provision for plug-in input filter
17 Provision for plug-in heterodyner

Analysis Options

21 60-db dynamic range
22 72-db dynamic range
23 100 resolution elements synthesized
24 200 resolution elements synthesized
25 300 resolution elements synthesized
26 400 resolution elements synthesized
27 Interpolated Analysis Ranges (interpolated between the five standard ranges)
28 Continuous vernier control of resolution between decade switch positions
29 Programmed variation of resolution to be frequency- and/or time-dependent under user's control
30 Non-standard Analysis Ranges
31 Gaussian selectivity characteristic
32 $(\sin x/x)^2$ selectivity characteristic
33 Customer-specified selectivity characteristic
34 Input-output linearity ± 0.25 db
35 Amplitude vs. frequency flatness (at center of filters) ± 0.25 db

Output Options

41 Square-law spectrum output (power spectral density function)
52 Digitized output

Digital Options

51 Digitized input
52 Digitized spectrum output
53 Digitized memory output
54 Digitized display sweep

Control Options

61 Fixed locations of Analysis Ranges as specified by customer
62 Relay control of Analysis Range switches
63 Relay control of display period switches
64 Rear terminals in parallel with front-panel terminals
65 Rear terminals instead of front-panel terminals

Presentation Options

71 Frequency marker output at separate terminals
72 Unblanking waveform in synchronism with spectrum-display sweep voltage

Packaging Options

81 Militarized — to meet military environment and performance specifications
82 Rack mounting
83 Slide mounting

Miscellaneous Options

91 Special paint
92 Non-standard power line voltages (note that standard unit accepts power line frequencies from 50 to 405 Hz, but limited to single-phase 117 volts ± 10%)

Input Accessories

111 Radio-frequency converter
112 Frequency-equalization unit
113 Automatic-gain-control unit
114 Preamplifier unit
115 Digital input buffer
116 Time code generator

Output Accessories

121 Digital recording buffer
122 Card punch buffer
123 Paper tape buffer
124 FM recording adaptor
125 Built-in X-Y plotter
126 Built-in display oscilloscope
127 Built-in chart recorder
128 Hard-copy and film-intensity modulation recorder
129 Spectrum averager
130 Probability density computer
131 Real-Time Contour Spectrograph™ — this attachment plots the spectrum as a topographical map in which the Cartesian coordinates are frequency and time, and the "height" contours show spectrum amplitude.
132 Immediate System Characterizer™ — measures spectra, cross-power spectrum, autocorrelation and cross-correlation functions of two signals. If signals are simultaneous input and output of a system, the system-transfer function is also measured. All in real time.

SPECIFICATIONS – MODEL UA7

Signal to be Analyzed

Minimum Detectable Signal	0.12 millivolts rms
Minimum Signal for Maximum Output	30 millivolts rms
Maximum Signal Input	30 volts rms
Input Impedance (Two Input Terminals)	(1) 50,000 ohms; (2) 600 ohms; a-c coupled on ranges A and B; d-c coupled on ranges C, D and E
Input Attenuator	60 db, with 5-db calibrations
Input-Level Monitor	Meter
Input-Output Linearity	± 1 db
External Frequency Marker Input	0.1 volt rms into 1,000 ohms

The following are applicable to ranges A and B only:

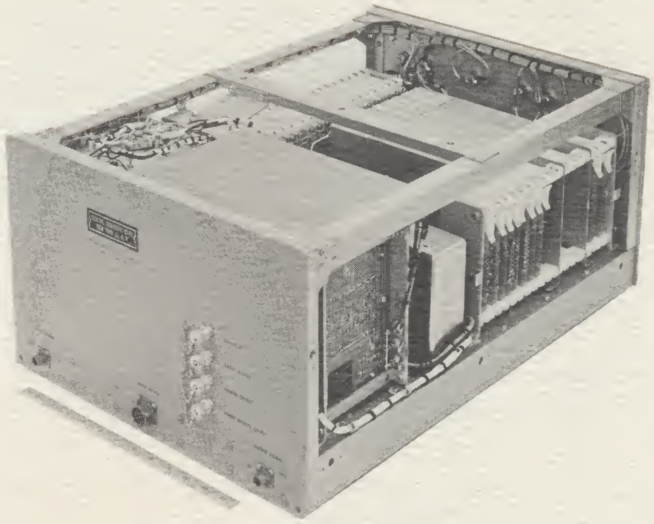
Stability of Internal Local Oscillator	±1 Hz per minute; greater stability available with fixed internal oscillators
Numerical Display of Frequency Location of Analysis Range	± 10 Hz quantization over the 1 MHz tuning range
External L. O. Input	0.3 volts rms ± 25 percent into 1,000 ohms, a-c coupled
L. O. Output	1 volt rms into 1,000 ohms; a-c coupled

Signal Spectrum

Spectrum Output	
LIN (linear)	5 volts peak into 600 ohms;
LOG (logarithmic)	5 volts peak into 600 ohms
Spectrum Scan Direction	Low to high frequency
Dynamic Range	48 db; 60-db and 72-db options available
Amplitude Flatness vs. Frequency (at centers of synthesized filters)	± 0.8 db

Spectrum Display

Scan Trigger Input	+6 volts into 1,000 ohms; pulse width 1 to 10 usec
Sweep Output	0 to +2 volts into 1,000 ohms; d-c coupled
Scope Trigger Output	+6 volts into 1,000 ohms; 1-usec pulse
Filter Step Pulse Output	+6 volts into 1,000 ohms; 1-usec pulse



Photograph of the Militarized Version of the Ubiquitous™ Spectrum Analyzer with Cover Removed, Showing Rear Panel

Direction of Display	Low frequency to high frequency
Frequency Markers	Ten markers, uniformly spaced across analysis range

Transient Capture and Time-Domain Display

Memory Contents Output	0.5 volts peak to peak into 100 ohms; a-c coupled
Hold Command Input	+6 volts into 1,000 ohms; pulse width 1 to 10 usec
Circulation Sync. Output	+6 volts into 1,000 ohms; 1-usec pulse

Other

Power (Power Plug — 3-Wire Polarized Type)	117 volts ± 10 percent; 50 to 405 cps single phase; 75 watts
Physical Dimensions (For 19″ RETMA Rack Mounting)	17″ wide, 12¼″ high, 22″ deep
Operating Temperature	+15° C. to +50° C.
Cooling and Ventilation	None required, because of low power consumption and unvented cabinet
Storage Temperature	–55° C. to +125° C.
Manual of Operation and Maintenance	Two copies furnished with each instrument
Warranty	Twelve-month warranty

Specifications subject to change without notice.